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A QUANTITATIVE MINERALOGICAL CLASSIFICATION OF IGNEOUS ROCKS—REVISED

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PART II

CLASS 2, ORDER I

- (210) **Meso-silexite.** See note under (110).
- (211) **Moyite.** The rocks of this family are quartz-orthogranites. Since three of the rocks described by Daly¹ from the Moyie sill along the Forty-ninth Parallel are of this uncommon type, the term moyite is here suggested for the family name.
- (215) **Rockallite** JUDD. The name rockallite is derived from the Island of Rockall, off the coast of Ireland. Judd² describes the rock as composed of aegirite, quartz, and albite. While the presence of aegirite makes the rock abnormal, the term may be used, at least temporarily, for the family name. Rockallite is a quartz-rich aegirite-albite-tonalite.
- (216) **Orthogranite.** This is a comparatively rare rock, only differing from normal granite in containing no plagioclase. In this group also belong anorthoclase-granite, potash-rhyolite (orthorhyolite), comendite, and some grorudites and solvsbergites. Many of the granites belonging here are aegirite- or riebeckite-bearing. For the use of the prefix "ortho-" see (111).
- Microcline-granite.
- Anorthoclase-granite.
- Orthogranitite.

¹ Reginald A. Daly, "Geology of the North American Cordillera at the Forty-ninth Parallel," *Geol. Surv. Canada, Mem.* 38, Part I, pp. 229, 230, 231.

² J. W. Judd, "On the Petrology of Rockall," *Trans. Royal Irish Acad. Dublin*, XXI (1897), 49-57.

Orthorhyolite is the extrusive equivalent of this family.

Comendite BERTOLIO¹ is an aegirite-rhyolite.

Paisanite OSANN. Paisanite was named from Paisano Pass, Texas, by Osann.² It is a dike rock composed of quartz, microperthite, and riebeckite.

(217) **Albite-granite.** The term albite-granite is here applied to a normal granite containing orthoclase and plagioclase between the proportions 95:5 and 65:35. The plagioclase, however, is albite, and not the usual oligoclase. A new name should be chosen, since the terms soda-granite, albite-granite, albite-syenite, etc., have been used for rocks with albite as the only feldspar, that is, for rocks which properly are called albite-tonalite, albite-diorite, etc., in this classification.

Albite-rhyolite. The extrusive equivalent of the preceding. The objection to the term albite-granite applies also to albite-rhyolite.

(218) **Albite-adamellite.** No confusion can result from the use of this term, since adamellite conveys the idea of a quartz-monzonitic rock, and the prefix indicates that the plagioclase of the orthoclase-plagioclase combination is albite. A number of grorudites fall here, as does also a lindoite, and numerous arfvedsonite- and riebeckite-granites, so called.

Albite-dellenite. The extrusive of the preceding.

(219) **Albite-granodiorite.** There is no possibility of misunderstanding this name. See notes under (218) and (229).

Albite-rhyodacite. See note under (229).

(2110) **Albite-tonalite.** The meaning of this term also is unmistakable. See note under (217). For the use of tonalite for quartz-diorite see (2210).

Albite-dacite. The extrusive of preceding.

¹ S. Bertolio, "Sulle comenditi, nuovo gruppo di rioliti con aegirina," *Atti. della Reale Accad. dei Lincei, Cl. scienze fisiche, mat. e nat.*, IV (1895), 2 semestre, pp. 49-50.

² A. Osann, "Report on the Rocks of Trans-Pecos, Texas," *4th Ann. Rept. Geol. Surv. Texas* (1892), p. 132.

(2111) **Orthosyenite.** This family includes syenites with orthoclase, microcline, microperthite, or anorthoclase, but with less than 5 per cent plagioclase.

Orthotrachyte. The extrusive equivalent of the preceding.

(2112) **Albite-syenite.** A term less likely to be misunderstood should be chosen for this family. See note under (217).

Albite-trachyte. See note under (217).

(2113) **Albite-monzonite.** This term cannot be misunderstood. See note under (218).

Albite-latite. The extrusive equivalent of the preceding.

(2114) **Albite-monzodiorite.** See note under (218). For the use of monzodiorite see (2214).

Albite-andelatite. The extrusive equivalent of the preceding. See note under (2214).

(2115) **Albite-diorite.** This term also is unmistakable. The word diorite conveys the impression of a plagioclase rock, and the prefix suggests that this feldspar is albite. The term soda-syenite has been used for this rock, but it was badly chosen. Soda-syenite naturally suggests a syenite rich in soda feldspar, but not to the exclusion of orthoclase. Albite-diorite is a much better term.

Albite-andesite. The extrusive equivalent of the preceding.

(2116) **Pulaskite WILLIAMS.** This term is used in the sense of Williams¹ original definition: "a rock made up of orthoclase, pyroxene, amphibole, and *a little* eleolite or its decomposition product, analcite." In another place² he says that the orthoclase is "similar to Brögger's kryptoperthite, although the amount of soda is somewhat less than is usually found in this." The rock, therefore, clearly falls into (2116), for while the dark constituents are not prominent they are greater than 5 per cent, as was shown by the examination of various thin sections from the type locality. Brögger's³ type laurvikite belongs here, but the

¹ J. Francis Williams, "The Igneous Rocks of Arkansas," *Ann. Rept. Geol. Surv. Arkansas for 1890*, II, 20.

² *Ibid.*, p. 60.

³ W. C. Brögger, *Die Eruptivgesteine des Kristianiagebietes. III: Das Ganggefölge des Laurdalits* (Kristiania, 1898), p. 30.

characteristic texture of this rock excludes it from representing the family.

(2121) **Ortho-nephelite-syenite, ortho-leucite-syenite.** This is nephelite- (or leucite-) syenite without plagioclase.

Orthofoyaite. See note under (2222).

Orthoditroite. See note under (2222).

Orthophonolite. The extrusive equivalent of the preceding.

(2122) **Albite-nephelite-syenite, albite-leucite-syenite.** Nephelite-(leucite-) syenites carry orthoclase either as the only feldspar or in combination with plagioclase, which may be albite or some other member of the series. In this family (2122) belong those carrying albite.

Albite-foyaite. See note under (2222).

Albite-ditroite. See note under (2222).

Albite-phonolite. The extrusive corresponding to the preceding.

(2123) **Albite-nephelite-monzonite.** Here belong numerous tinguaite and so-called nephelite-syenites, also a sodalite-foyaite and a cancrinite-syenite. Covite WASHINGTON, according to the calculated mode, belongs here, but under the definition Washington¹ says the rock is a "leucocratic combination of orthoclase and less nephelite with hornblende and aegirite-augite," which would place it in Family 21.

(2124) **Litchfieldite BAYLEY.** In his description of litchfieldite Bayley² says: "As was indicated by the microscopic study, no plagioclase other than albite is present, and this, as seen (from a calculated mode), is largely in excess of the orthoclase." The mode computed from the analysis indicates 27 per cent orthoclase and microcline, 47 per cent albite, 17 per cent nephelite, and 2 per cent cancrinite. These proportions are about the same as shown by the thin section and Thoulet separation. While cancrinite occurs in the type rock, Bayley³ says: "I do not regard

¹ Henry S. Washington, "The Foyaite-Ijolite Series of Magnet Cove: A Chemical Study of Differentiation," *Jour. Geol.*, IX (1901), 615.

² W. S. Bayley, "Eleolite-Syenite of Litchfield, Maine," *Bull. Geol. Soc. Amer.*, III (1892), 242.

³ *Ibid.*, *In litteris*, June 14, 1919.

cancrinite as an essential constituent . . . and many of the specimens show none. . . . Some of it is certainly secondary." The rocks of this family may therefore be divided into

Litchfieldite (normal).

Cancrinite-litchfieldite.

The calculated mode of canadite QUENSEL¹ places it in this family, but the actual mineral composition may be quite different. Quensel² says that "a rock entirely consisting of nephelite, albite, and a mafic mineral may or may not be a canadite, depending upon the presence or absence of a certain amount of normative limefeldspar." Depending thus upon chemical composition for its name, it is excluded here.

(2125) Mariupolite MOROZEWICZ. Morozewicz³ described certain rocks from the shores of the Sea of Azof which consist of much albite, less nephelite, and some ferromagnesian constituents and zircon. He gives two modal analyses, determined microscopically, both of which fall in this family somewhat above the center point.

(2126) Naujaite USSING. Several nephelite- and leucite-syenites belong here, as does also arkite WASHINGTON.⁴ The latter, however, is too poor in feldspar to be typical of the family, and it carries garnet as an essential. Naujaite USSING⁵ is the rock originally described by Steenstrup⁶ as a sodalite-syenite. Pending the location of a nephelite-rich orthofoyaite or orthoditroite, naujaite may represent the family.

Syn.: Sodalite-syenite STEENSTRUP.

Arkite WASHINGTON.

¹ Percy Quensel, "The Alkaline Rocks of Almunge," *Bull. Geol. Inst. Upsala*, XII (1914), 135, 176-77.

² *In litteris*, May 16, 1915.

³ J. Morozewicz, "Über Mariupolit, ein extremes Glied der Eleolithsyenite," *Tscherm. Min. Petr. Mitth.*, XXI (1902), 245.

⁴ Henry S. Washington, "The Foyaite-Ijolite Series of Magnet Cove: A Chemical Study in Differentiation," *Jour. Geol.*, IX (1901), 617.

⁵ N. V. Ussing, "Geology of the Country around Julianehaab, Greenland," *Meddel. om Grönl.*, XXXVIII (1911), 32, 143-56.

⁶ K. J. V. Steenstrup, "Bemaerkninger til et geognostisk Oversigtskaart over en Del af Julianehaabs Distrikt (den 20 Juni 1878)," *Meddel. om Grönl.*, II (1881), 35.

(2127) **Beloeilite.** O'Neill¹ described a "feldspathic tawite" from Mount St. Hilaire (Beloeil), Quebec, intermediate in composition between sodalite-syenite and tawite. This rock may be called beloeilite and may serve as the type of the sodalite rocks of the family.

(2129) A soda-sussexite of Hackman² and a nephelite-sodalite-syenite of O'Neill³ belong here.

(2130) **Toryhillite.** Adams and Barlow⁴ described a nephelite-rich albite rock from Toryhill, Monmouth Township, Ontario. The rock falls near the center point of this family; therefore a new name is here suggested.

(2131) **Urtite** RAMSAY. Urtite is a feldspar-free nephelite rock, described by Ramsay.⁵ The name is derived from the second part of Lujavr-Urt, where the rock was first found. It consists of 82 to 86 per cent nephelite, 12 to 18 per cent aegirite-augite, and 2 per cent apatite. Ijolite RAMSAY and BERGHELL,⁶ with 51.6 per cent nephelite, and monmouthite ADAMS and BARLOW,⁷ with 77.6 per cent feldspathoid (of which 72 is nephelite), also belong here. The leucite rock of this family is fergusite PIRSSON.⁸ Only a single occurrence is known. It consists of 65 per cent pseudoleucite and 35 per cent mafites, chiefly diopside. The melilite rock of the family is represented by uncompahgrite LARSEN.⁹ It is a

¹ J. J. O'Neill, "St. Hilaire (Beloeil) and Rougemont Mountains, Quebec," *Geol. Surv. Canada, Mem.* 43 (Ottawa, 1914), p. 46.

² V. Hackman, "Neue Mitteilungen über das Ijolithmassiv in Kuusamo," *Bull. d. l. Comm. Geol. d. Finlande*, No. 11 (Helsingfors, 1899), p. 24.

³ J. J. O'Neill, *op. cit.*, p. 41.

⁴ Frank D. Adams and Alfred E. Barlow, "Geology of the Haliburton and Bancroft Areas, Province of Ontario," *Geol. Surv. Canada, Mem.* 6 (1910), p. 273.

⁵ Wilhelm Ramsay, "Urtit, ein basisches Endglied der Augit-syenit-Nephelinsyenit-Serie," *Geol. Fören. i. Stockh. Förhandl.*, XVIII (1896), 463.

⁶ Wilhelm Ramsay and Hugo Berghell, "Das Gestein vom Iiwaara in Finland," *Geol. Fören. i. Stockh. Förhandl.*, XIII (1891), 304; also V. Hackman, *op. cit.*, *supra*, p. 20.

⁷ Frank D. Adams and Alfred E. Barlow, *op. cit.*, p. 277.

⁸ Louis Valentine Pirsson, "Petrography and Geology of the Igneous Rocks of the Highwood Mountains, Montana," *U.S. Geol. Surv., Bull.* 237 (1905), p. 88.

⁹ Esper S. Larsen, "Melilite and Other Minerals from Gunnison County, Colorado," *Jour. Wash. Acad. Sci.*, IV (1914), 473.

deep-seated rock consisting of two-thirds melilite and one-third dark constituents (magnetite and pyroxene) with some accessory perovskite and apatite. The extrusive equivalent is melilite-basalt STELZNER¹ (Syn. Melilithit LOEWINSON-LESSING²).

CLASS 2, ORDER 2

(222) **Quartz-granite.** Since the term granite in itself carries the idea of a quartz-bearing rock, the term quartz-granite will indicate a granite that is rich in quartz. All other rocks which, by definition, carry quartz may be similarly qualified, namely, adamellite, granodiorite, tonalite, etc.

(223) **Quartz-adamellite.** See note under (222). Here belongs, though far from the center point, the Hauksuo, Kisko, aplite, described by Eskola,³ which consists of quartz 48.9 per cent, plagioclase (average $Ab_{85}An_{15}$) 22.9 per cent, microcline 20.4 per cent, biotite 4.4 per cent, magnetite 1.9 per cent, and epidote 1.5 per cent.

(224) **Quartz-granodiorite.** See note under (222).

(225) **Quartz-tonalite.** See note under (222). For the use of tonalite for quartz-diorite see (2210).

(227) **Granite.** This term is of very old date. It is not found in Pliny. Breislak says it was first used by Caesalpinus⁴ in 1596. The name may be derived from the Italian *granito*, "grained" (Lat. *granum*), but its origin is uncertain. The word is similar in sound in many languages, for example, *gwenith faen* ("wheat stone") in Welsh, and it is possible that the name was brought from Wales by the Romans who built roads and worked the mines there about 78 A.D.

Family (227) is that of the normal granites. These rocks consist of quartz, orthoclase, less oligoclase or andesine, and a moderate

¹ Alfred Stelzner, "Mittheilungen an den Redaction," *Neues Jahrb.*, I (1882), 230-31; also "Über Melilith und Melilithbasalte," *Neues Jahrb.*, B.B., II (1882), 364-440.

² F. Loewinson-Lessing, "Kritische Beiträge zur Systematik der Eruptivgesteine, IV," *T.M.P.M.*, XX (1901), 114.

³ Pentti Eskola, "On the Petrology of the Orijärvi Region in Southwestern Finland," *Bull. d. l. com. géol. d. Finlande*, No. 40 (1914), p. 83.

⁴ Andreas Caesalpinus (Cesalpino), *De Metallicis* (1596), II, cap. 11.

amount of mafic minerals. There are many subfamilies, depending upon the accessories or dark constituents.

Granitite. This is an old term which has been used with a great variety of meanings. So long ago as 1823 von Leonhard¹ said that the proposal to call granites with accessory minerals granitite was superfluous and unfitting. Rose² used the word for muscovite-free biotite-bearing rocks with quartz, orthoclase, and considerable oligoclase. It was used in the same sense by Senft³ and Rosenbusch,⁴ and is here also used as a synonym for biotite-granite. Cathrein's⁵ suggestion that it be used for plagioclase-rich hornblende-bearing granites has never been followed.

Amphibole-granite.

Arfvedsonite-granite BRÖGGER.⁶

Augite-granite.

Binary-granite KEYES⁷ contains both muscovite and biotite. It is also called two-mica granite.

Hypersthene-granite.

Syn.: Charnockite HOLLAND.⁸

Microcline-granite.

Muscovite-granite.

Tourmaline-granite, etc.

Rhyolite VON RICHTHOFEN. The name rhyolite (from *ῥόαξ*, "lava stream," "torrent") was given by von Richthofen⁹ to the extrusive equivalent of granite on account of its usual fluidal

¹ K. C. von Leonhard, *Charakteristik der Felsarten* (Heidelberg, 1823), I, 54.

² Gustav Rose, "Ueber die zur Granitgruppe gehörenden Gebirgsarten," *Zeitschr. d. d. geol. Ges.*, I (1849), 386; also pp. 363-66.

³ Ferdinand Senft, *Classification und Beschreibung der Felsarten* (Breslau, 1857), p. 297.

⁴ H. Rosenbusch, *Mikroskopische Physiographie der massigen Gesteine* (1st ed.; Stuttgart, 1877), II, 20-21.

⁵ A. Cathrein, "Zur Dünnschliffsammlung der Tiroler Eruptivgesteine," *Neues Jahrb.*, I (1890), 72.

⁶ W. C. Brögger, "Die Mineralien der Syenitpegmatitgänge der südnorwegischen Augit- und Nephelinsyenite," *Zeit. f. Kryst.*, XVI (1890), 68.

⁷ Charles Rollin Keyes, "Origin and Relations of Central Maryland Granites," *U.S. Geol. Surv., Ann. Rept.*, XV (1895), 714.

⁸ T. H. Holland, "The Charnockite Series, a Group of Archean Hypersthene Rocks in Peninsular India," *Mem. Geol. Surv. India*, XXVII (1900), 2, 119.

⁹ Ferdinand Freiherrn v. Richthofen, "Studien aus den ungarisch-siebenbürgerischen Trachytgebirgen," *Jahrb. d. k. k. geol. Reichsanst.*, XI (1860), 156.

character. Roth¹ called the same rocks liparites, from the Lipari Islands, where they occur.

Syn.: Liparite ROTH.

Nevadite VON RICHTHOFEN. Nevadite is a variety of rhyolite with very abundant phenocrysts and very little ground-mass. It was named by von Richthofen² from its occurrence in Nevada.

(228) Adamellite CATHREIN-BRÖGGER. The term adamellite is here given to quartz-monzonites. It was originally used by Cathrein³ for rocks from Adamello which contain both orthoclase and plagioclase. Speaking of these rocks he says: "Er ist ein lichtetes, schon im Aussehen mehr den Graniten als Dioriten sich näherndes Gestein." Brögger⁴ uses the name for acid quartz-monzonites, and Ball⁵ and Hatch⁶ use it for quartz-monzonite.

Syn.: Quartz-monzonite BRÖGGER.

Windsorite DALY.⁷ This is a quartz-poor quartz-monzonite dike-rock.

Dellenite BRÖGGER. The rock intermediate between dacite and rhyolite from Dellen, Helsingland, Sweden, was named dellenite by Brögger,⁸ and the term is here used for the extrusive equivalent of quartz-monzonite. Since it consists of a single word it is preferable to quartz-latite.

Syn.: Quartz-latite RANSOME,⁹ Dacite-liparite BRÖGGER.¹⁰

¹ Justus Roth, *Gesteinsanalysen*, xxxiv (1861).

² F. Baron von Richthofen, "Principles of the Natural System of Volcanic Rocks," *Mem. Cal. Acad. Sci.*, I (1868), Part II, p. 16.

³ A. Cathrein, "Zur Dünnschliffsammlung der Tiroler Eruptivgesteine," *Neues Jahrb.*, I (1890), 74.

⁴ W. C. Brögger, *Die Eruptivgesteine des Kristianiagebietes. II: Die Eruptionsfolge der triadischen Eruptivgesteine bei Predazzo in Südtirol* (Kristiania, 1895), p. 61.

⁵ Sydney H. Ball, "General Geology of the Georgetown Quadrangle, Colorado," *U.S. Geol. Surv. Wash., Prof. Paper* 63 (1908), p. 51.

⁶ F. H. Hatch, *The Petrology of the Igneous Rocks* (London, 1914), p. 176.

⁷ R. A. Daly, "The Geology of Ascutney Mountain, Vermont," *U.S. Geol. Surv., Bull.* 209 (1903), p. 46.

⁸ W. C. Brögger, *Die Eruptivgesteine des Kristianiagebietes. II: Die Eruptionsfolge der triadischen Eruptivgesteine bei Predazzo in Südtirol* (Kristiania, 1895), p. 59, note.

⁹ F. Leslie Ransome, "Some Lava Flows of the Western Slope of the Sierra Nevada, California," *Amer. Jour. Sci.*, V (1898), 372.

¹⁰ W. C. Brögger, *op. cit.*, p. 60.

(229) Granodiorite BECKER. The term granodiorite was suggested by Becker¹ for plutonic rocks containing both orthoclase and acid plagioclase, the latter in excess of the former. The name was first published in a paper by Lindgren² in 1893 and described in more detail later.³ Lindgren⁴ says: "The truly characteristic feature of the granodiorites is that the soda-lime feldspar, which always is a calcareous oligoclase or an andesine, is *at least* equal to double the amount of the alkali feldspar. The latter may be taken to vary from 8 per cent to 20 per cent" in a rock with an assumed feldspar content of 60 per cent.⁵ "Below the lower limit the rock becomes a quartz-diorite: above the upper a quartz-monzonite." "In the quartz-monzonite," he continues, "I would give this mineral a range from 20 per cent to 40 per cent," again assuming a total of 60 per cent feldspar. His divisions, therefore, based on the orthoclase-plagioclase ratio are $0-13\frac{1}{3}-33\frac{1}{3}-66\frac{2}{3}$ for quartz-diorite, granodiorite, and quartz-monzonite. In the present classification the divisions are taken at 0-5-35-65, the writer believing that more than 5 per cent of orthoclase changes the character of a quartz-diorite too much for it to retain that name. Setting apart as orthogranite the rock with 95 to 100 per cent of its feldspar orthoclase, and as quartz-diorite that having 95-100 per cent plagioclase, the remaining 90 parts are divided into three

¹ Waldemar Lindgren, "Granodiorite and Other Intermediate Rocks," *Amer. Jour. Sci.*, IX (1900), 270.

² *Ibid.*, "The Auriferous Veins of Meadow Lake, California," *Amer. Jour. Sci.*, XLIV (1893), 202.

³ *Sacramento Folio*, U.S. Geol. Surv., No. 5, 1894; *Placerville Folio*, No. 3, 1894; *Smartsville Folio*, No. 18, 1895; *Nevada City Folio*, No. 29, 1896; *Pyramid Peak Folio*, No. 31, 1896; *Truckee Folio*, No. 39, 1897; H. W. Turner, "The Rocks of the Sierra Nevada," *U.S. Geol. Surv.*, An. 14, pp. 478, 482; Waldemar Lindgren, "The Gold-Silver Veins of Ophir, California," An. 14, *U.S. Geol. Surv.*, Part II (1894), pp. 252, 255-56; also "The Gold Quartz Veins of Nevada City and Grass Valley Districts, California," An. 17, *U.S. Geol. Surv.*, Part II (1896), p. 35; "The Granitic Rocks of the Pyramid Peak District, Sierra Nevada, California," *Amer. Jour. Sci.*, III (1897), 308; "The Granitic Rocks of Sierra Nevada," *Abstr. in Science*, New Series, V (1897), 361; "Granodiorite and Other Intermediate Rocks," *Amer. Jour. Sci.*, IX (1900), 269-82.

⁴ Waldemar Lindgren, "Granodiorite and Other Intermediate Rocks," *Amer. Jour. Sci.*, IX (1900), 277.

⁵ *Ibid.*, p. 279.

equal portions, one each for normal granite, quartz-monzonite, and granodiorite.

The term granodiorite is not the most satisfactory, from the standpoint of the construction of the word, for a rock intermediate between quartz-monzonite (adamellite) and quartz-diorite (tonalite), for it suggests a rock intermediate between a granite (an orthoclase-quartz-bearing rock) and a diorite (a plagioclase-quartz-free rock), that is, a quartz-monzonite. Monzonite in the sense in which we now use it, however, was not introduced by Brögger until 1895, while granodiorite was first used in 1892 or 1893. The term was intended to convey the idea of a diorite with granitic characters, that is, with quartz and a certain amount of orthoclase, but upon the introduction of the term monzonite Lindgren¹ found it advisable to restrict the "definition of granodiorite to rocks considerably nearer quartz-diorite than originally intended." A name derived from the rocks between which granodiorite, as now defined, actually stands would give adam-tonalite, which is hardly euphonious, to say the least. Furthermore, the term granodiorite is so firmly established and was so clearly defined that it should not be changed.

The term banatite was used by Brögger² for his intermediate quartz-monzonites, and under this term are included rocks which are probably to be classed as quartz-poor granodiorites (see under 2213).

The objection to the construction of the word granodiorite as applied to rocks under the present definition applies also to the terms introduced by the present writer³ in 1917, namely granogabbro, syenodiorite, and syenogabbro. But since granodiorite is retained for the reasons stated above, and adam-gabbro is as objectionable as adam-diorite, granogabbro (239) also will be retained to make analogous terms. The names of the extrusive rocks should naturally conform in construction to their deep-seated equivalents; consequently rhyodacite WINCHELL is used for the

¹ Waldemar Lindgren, *In litteris*, June 17, 1919.

² W. C. Brögger, *Die Eruptivgesteine des Kristianiagebietes. II: Die Eruptionsfolge der triadischen Eruptivgesteine bei Predazzo in Südtirol* (Kristiania, 1895), p. 60.

³ Albert Johannsen, "Suggestions for a Quantitative Mineralogical Classification of Igneous Rocks," *Jour. Geol.*, XXV (1917), p. 89.

granodioritic extrusive, and rhyobasalt is here proposed for the granogabbroic. Syenodiorite and syenogabbro will be replaced by the better terms monzodiorite and monzogabbro. For the corresponding extrusives, ande-latite and basa-latite are here proposed.

Rhyodacite WINCHELL.¹ See note under granodiorite above. This is the extrusive equivalent of granodiorite.

(2210) Tonalite vom RATH-BRÖGGER-SPURR. Tonalite was applied by vom Rath² to a certain rock from Monte Tonale, in the Tyrol. It consists of abundant quartz, andesine, very small amounts of orthoclase as an accessory, and a dark mineral. In the definition, however, vom Rath omitted the orthoclase, which occurs as micropegmatite and was regarded simply as an accessory, and said: "Der Tonalit enthält in körnigem Gemenge als wesentliche Bestandtheile: eine trikline Feldspath-Species, Quarz, Magnesiaglimmer und Hornblende." In his tabulation Brögger³ used tonalite for acid quartz-diorite, and in another place⁴ he said: "Der Name Tonalit wäre dann den Quarzdioriten vorbehalten." Since Brögger does not use the subdivision granodiorite, his tonalite includes some of these rocks. Simply as quartz-diorite the term was used by Spurr,⁵ who adopted it as a group name instead of quartz-diorite, because it "is shorter and more characterizing." In the same sense it was used by Winchell⁶ and Hatch,⁷ and it is so used here,

Incidentally, the average igneous rock of Clarke,⁸ computed into common minerals, falls in this family. It contains quartz

¹ Alexander N. Winchell, "Rock Classification on Three Co-ordinates," *Jour. Geol.*, XXI (1913), 214.

² G. vom Rath, "Beiträge zur Kenntniss der eruptiven Gesteine der Alpen," *Zeitschr. d. d. geol. Ges.*, XVI (1864), 250.

W. C. Brögger, *Die Eruptivgesteine des Kristianiagebietes. II: Die Eruptionsfolge der triadischen Eruptivgesteine bei Predazzo in Südtirol* (Kristiania, 1895), p. 60.

⁴ *Ibid.*, p. 61.

⁵ J. E. Spurr, "Reconnaissance in Southwestern Alaska in 1898," *U.S. Geol. Surv., Ann. Rept.*, XX, Part VII (1900), p. 190.

⁶ Alexander N. Winchell, "Rock Classification on Three Co-ordinates," *Jour. Geol.*, XXI (1913), 214.

⁷ F. H. Hatch, *The Petrology of the Igneous Rocks* (London, 1914), p. 195.

⁸ F. W. Clarke, "Data of Geochemistry," *U.S. Geol. Surv., Bull.* 491 (1911), p. 31.

12 per cent, andesine 59.2 per cent, pyribole 16.8 per cent, mica 3.8 per cent, and other accessories 7.9 per cent.

Syn.: Quartz-diorite.

Dacite STACHE. The name dacite was given by Stache¹ to certain older quartz-trachytes, found in Siebenbürgen (Dacia), which contain oligoclase and pyroxene and which were thus thought to be separated from the younger quartz-trachytes or rhyolites which contain sanidine and biotite. The term has been variously used by different petrographers, some applying it only to extrusive plagioclase rocks with quartz phenocrysts, others including rocks whose only quartz is in the groundmass; some requiring the presence of pyroxene, others including rocks with biotite. In general the name has come to mean quartz-andesite, the extrusive equivalent of quartz-diorite, and it is so used here.

Syn.: Quartz-andesite.

(2212) Syenite. The name syenite was used at least as long ago as the time of Pliny,² and was apparently in common use in his day for the rocks from Syene (Assuan), Egypt. "Circa Syenen vero Thebaidis Syenites," he says, "que ante pyrrhopocilon vocabant," that is, spotted with red. Werner³ applied the term Sienit to the hornblende-bearing rock from near Dresden, under the impression that the two were the same. It was later found that the Syene rock contains quartz, is, in fact, hornblende-granite, while the Dresden rock is practically quartz-free. Some writers consequently used the term syenite for hornblende-granite, but generally it was used for quartz-free orthoclase rocks in the sense of Werner. Rosière⁴ found that the rock of Mount Sinai is of the quartz-free variety and therefore proposed that the name be changed to sinaite. The older term, however, was in such common use that this suggestion was not followed.

¹ G. Stache, "Quarztrachyte Siebenbürgens," in Fr. von Hauer and G. Stache, *Geologie Siebenbürgens* (1863), pp. 56, 70, 79.

² C. Plinii Secundi *Naturalis historiae* xxxvi. cap. viii. In the edition Lugd. Batav. Roterodami, Ao. 1668, p. 647.

³ "Vermischten Nachrichten," *Bergmännisches Journal*, II (1788), 824.

⁴ J. F. d'Aubuisson de Voisins, *Traité de géognosie* (Strasbourg et Paris, 1819), p. 21.

There are many varieties of syenite, depending upon the character of the dark or accessory constituents.

Biotite syenite.

Syn.: Syenitite LOEWINSON-LESSING,¹ analogous to granitite for biotite-granite. Polenov,² however, had previously used the term in a different sense, namely for syenite-aplite.

Hornblende-syenite.

Arfvedsonite-syenite.

Augite-syenite.

Epidote-syenite.

Pyroxene-syenite.

Hypersthene-syenite (Syn.: Mangerite), etc.

Trachyte HAÜY. The term trachyte, from the Greek *τραχύς*, on account of the rough appearance of the rock, was introduced by Haüy³ in his lectures at the Jardin des Plantes to characterize the rocks from the Drachenfels on the Rhine. Although the feldspar in these rocks had previously been determined and named sanidine by Nose,⁴ yet plagioclase rocks of the general appearance of the original trachyte came to be included in the term. Later, von Buch⁵ separated certain Andean extrusives with plagioclase from this group and called them andesites. At the present time trachyte is used for the extrusive equivalents of syenite, that is, for rocks consisting of potash-feldspar, a little plagioclase, and a biopyribole. Many trachytes are orthotrachytes (2111).

(2213) Monzonite DE LAPPARENT-BRÖGGER. The principal rock of Monzoni, in the Tyrol, is of quite variable character. It

¹ F. Loewinson-Lessing, "Kritische Beiträge zur Systematik der Eruptivgesteine, II," *Tscherm. Min. Petr. Mitth.*, XIX (1900), 173.

² B. Polenov, "Die massigen Gesteine von nördlichen Theile des Witim-Plateau," *Travaux de la Société Impériale des Naturalistes de St. Pétersbourg*, XXVII (1899), livr. 5, 464.

³ Haüy did not publish the name until 1822 in his *Traité de minéralogie* (2d ed.; Paris, 1822), IV, 579, but it was accredited to him as far back as 1813 in Alexandre Brongniart's "Essai d'une classification minéralogique des roches mélangées," *Jour. d. Mines*, XXXIV (1813), 43.

⁴ K. W. Nose, *Orographische Briefe*, I, 26, 113.

⁵ Leopold von Buch, "Ueber Erhebungscratere und Vulcane" (read in Berlin Akad., March 26, 1835), *Pogg. Ann.*, XXXVII (1836), 190.

was called Monzon-syenit by von Buch,¹ and later monzonit by De Lapparent.² The latter term served as a collective name for some years, but in 1881 Reyer³ used it as a specific name for rocks of the Monzoni type, which he thought to be augite-syenite. Earlier Tschermak⁴ had recognized the principal rock to be an orthoclase-plagioclase rock, but he applied the term monzonite to the whole series. Lemberg⁵ characterized the rock as intermediate between syenite and diorite. In those days rocks were classified either as syenites or diorites, and it was not until 1895 that an intermediate family was established. In that year Brögger⁶ introduced the monzonite family. He says: "Es ist . . . nach meiner Ansicht nothwendig, zwischen den Orthoklasgesteinen und den Plagioklasgesteinen . . . eine Übergangsordnung von Alkalifeldspath-Kalknatronfeldspath-Gesteinen einzuschieben." The plagioclase of the Monzoni rocks, according to Brögger, is generally andesine to labradorite, or even anorthite.⁷ Rosenbusch⁸ says that andesine is much rarer in all monzonites than more basic plagioclase, and more acid plagioclase than andesine had not been observed by him in the rocks of Monzoni. Elsewhere, it would seem, orthoclase-acid-plagioclase rocks are more common than those with basic plagioclase. In this classification, therefore, the more acid rocks, that is, those whose feldspar is oligoclase or andesine (sodiummonzonites), will be considered normal monzonites, while those with labradorite or bytownite will be included under the calciummonzonites (2313).

¹ Leopold von Buch, "Ueber geognostische Erscheinungen im Fassathale," v. Leonh. *Mineralogisches Taschenbuch für das Jahr 1824*, p. 347.

² M. de Lapparent, "La constitution géologique du Tyrol, méridional," *Ann. d. Mines*, 6 sér., VI (1864), 259.

³ Ed. Reyer, "Predazzo," *Jahrb. d. k. k. geol. Reichsanst.*, XXXI (1881), 36.

⁴ Gustav Tschermak, *Die Porphyrgesteine Österreichs* (1869), p. 110.

⁵ J. Lemberg, "Über die Contactbildungen bei Predazzo," *Zeitschr. d. d. geol. Gesell.*, XXIV (1872), 188, 190.

⁶ W. C. Brögger, *Die Eruptionsgesteine des Kristianiagebietes. II: Die Eruptionfolge der triadischen Eruptionsgesteine bei Predazzo in Südtirol* (Kristiania, 1895), pp. 22-23.

⁷ *Op. cit.*, p. 54.

⁸ H. Rosenbusch, *Elemente der Gesteinslehre* (Stuttgart, 1898), p. 108; also *Mikroskopische Physiographie der massigen Gesteine* (Stuttgart, 1907), II¹, 167.

Certain intrusive rocks in Banat, cutting through limestones and crystalline schists, were named banatites by von Cotta.¹ They are usually quartz-bearing, and are intermediate between quartz-diorites, quartz-augite-diorites, diorites, and augite-diorites. Brögger² applied the name to quartz-bearing monzonites, intermediate between normal monzonites and adamellites, and related to monzonites as quartz-syenites are to syenites. The extrusive equivalent of banatite BRÖGGER is quartz-trachyte-andesite BRÖGGER³ (see note under 229).

Olivine-monzonite. While the Monzoni olivine-monzonites carry basic plagioclase, elsewhere olivine-monzonites with andesine are found. These rocks, therefore, fall in the present subfamily. Kentallenite is stated by Hatch⁴ to be "identical with Brögger's olivine-monzonite. . . . The two feldspars are present in roughly equal proportions." As a matter of fact, Hill and Kynaston⁵ distinctly state that "the term (monzonite) has come to be associated with the presence of an approximately equal amount of the two feldspars—a feature which cannot be said to be an essential characteristic of our group." From the variation in the various specimens described, it would seem that kentallenite is an olivine-orthoclase-plagioclase rock, the ratio of the feldspars being quite variable, consequently not limited to Family 13 here.

Latite RANSOM. The name latite, from the occurrence of such rocks in the Italian province of Latium, was used by Ransom⁶ for the extrusive equivalents of the monzonites.

Syn.: Trachyte-andesite. (The term trachy-andesite has been used in a different sense from trachyte-andesite by some writers, though others make it synonymous. Rosenbusch⁷ uses

¹ B. von Cotta, *Erzlagertstätten im Banat und in Serbien* (Wien, 1864).

² W. C. Brögger, *op. cit.* (II, 1895), p. 61. ³ *Ibid.*, p. 60.

⁴ F. H. Hatch, *The Petrology of the Igneous Rocks* (London, 1914), pp. 206-7.

⁵ J. B. Hill and H. Kynaston, "On Kentallenite and Its Relation to Other Igneous Rocks in Argyllshire," *Quart. Jour. Geol. Soc.*, LVI (London, 1900), 532.

⁶ F. Leslie Ransome, "Some Lava Flows of the Western Slope of the Sierra Nevada, California," *Amer. Jour. Sci.*, V (1898), 372.

⁷ H. Rosenbusch, *Mikroskopische Physiographie der massigen Gesteine* (Stuttgart, 1908), II, 1036-37.

it, by analogy to trachydolerite, for an extrusive rock whose deep-seated equivalent would be intermediate between alkali-syenite and essexite. It represents, consequently, a rock carrying a feldspathoid or aegirite, riebeckite, etc., and not, as one would suppose from the name, a rock intermediate between trachyte and andesite.) (2214) **Monzodiorite.** The term syenodiorite was proposed by the writer¹ for the quartz-free equivalent of granodiorite. For the reasons stated under granodiorite (229), this term is withdrawn and monzodiorite is substituted for it.

Syn.: Syenite-diorite BRÖGGER.²

Andelatite. For the extrusive equivalent of monzodiorite, the term andelatite, as intermediate between andesite and latite, is suggested. See note under granodiorite (229).

Mugearite HARKER. Mugearite, from the village of Mugeary, is the name given by Harker³ to certain extrusive rocks resembling basalt but with oligoclase (Ab_7An_2) and much olivine. A modal analysis shows the rock to consist of oligoclase $57\frac{1}{2}$ per cent, orthoclase $12\frac{1}{2}$ per cent, olivine, iron ore, and augite (augite quite subordinate to olivine) $26\frac{1}{2}$ per cent, and apatite $3\frac{1}{2}$ per cent. It is therefore an olivine andelatite.

(2215) **Diorite HAÜY.** The term diorite (from $\delta\iota\omicron\pi\iota\varsigma\omega$, "distinct") was introduced by Haüy⁴ as a substitute for Werner's term *Grünstein*. The name now stands for a rock consisting of acid plagioclase and a dark mineral.

Syn.: Grünstein WERNER, Diabase BRONGNIART.

Oligoclase-diorite.

Andesine-diorite.

Andesite VON BUCH. Formerly there were included, under the name trachyte, not only orthoclase rocks, but those

¹ Albert Johannsen, "Suggestions for a Quantitative Mineralogical Classification of Igneous Rocks," *Jour. Geol.*, XXV (1917), 89.

² W. C. Brögger, "Die Mineralien der Syenitpegmatitgänge der südnorwegischen Augit- und Nephelinsyenite," Part I, *Zeit. f. Kryst.*, XVI (1890), 49.

³ Alfred Harker, "The Tertiary Igneous Rocks of Skye," *Geol. Surv. Mem.* (1904), p. 265; John S. Flett, "On the Mugearites," *Summary of Progress, Geol. Surv.* (1907), p. 119.

⁴ The term first appeared in the publications of some of Haüy's students. Thus see J. F. d'Aubisson de Voisins, *Traité de géognosie* (Strasbourg and Paris, 1819), p. 146. Later it was used in Abbé Haüy's *Traité de minéralogie* (Paris, 1822), IV, 540.

containing plagioclase as well. See note under trachyte (2212). In 1835 von Buch¹ described certain volcanic rocks from the Andes, consisting of plagioclase (originally thought to be albite) and hornblende. He named them andesites. Later the term was applied to oligoclase- or andesine-bearing rocks, and it is used in this sense here. The dark mineral may be biotite, hornblende, or augite, or combinations of these, which thus give subfamilies.

Biotite-andesite.

Mica-andesite.

Hornblende-andesite.

Syn.: Hungarite LANG,² named from their wide distribution in Hungary.

Augite-andesite. See note under basalt (2315).

Hypersthene-andesite BECKE.³

Syn.: Santorinite BECKE. Becke⁴ proposed the term santorinite for acid- and alboranite for basic rocks of Santorin. The former are hypersthene-andesites rich in soda ($\text{Na}:\text{Ca} > 2$). The phenocrysts are labradorite with mantles of oligoclase, while the groundmass is acid oligoclase. The average feldspar, therefore, is acidic. Washington⁵ had previously called the acid rocks pyroxene-andesites and had proposed the term santorinite for the members carrying basic plagioclase. Santorinite, used with two meanings, should therefore be abandoned.

(2217) Nephelite- (leucite-) bearing syenite.

(2218) Nephelite- (leucite-) bearing monzonite.

(2219) Nephelite- (leucite-) bearing monzodiorite.

(2220) Nephelite- (leucite-) bearing diorite.

(2222) Nephelite-syenite ROSENBUSCH. Rosenbusch⁶ included,

¹ Leopold von Buch, "Ueber Erhebungscratere und Vulcane" (read in Berlin Akad., March 26, 1835), *Pogg. Ann.*, XXXVII (1836), 190.

² Heinr. Otto Lang, *Grundriss der Gesteinskunde* (Leipzig, 1877), p. 196.

³ F. Becke, "Der Hypersthen-Andesit der Insel Alboran," *Tscherm. Min. Petr. Mitth.*, XVIII (1899), 553.

⁴ *Ibid.*, p. 553.

⁵ Henry S. Washington, "Italian Petrological Sketches: V. Summary and Conclusions," *Jour. Geol.*, V (1897), 368.

⁶ H. Rosenbusch, *Mikroskopische Physiographie der massigen Gesteine* (1st ed.; Stuttgart, 1877), II, 204.

under the names Eleolith-Syenit and Nephelin-Syenit, rocks which had previously been described as zircon-syenite, foyaite, miascite, and ditroite. If these terms were not acceptable he suggested that all of the rocks of this class be included under foyaite, since the rocks from Mount Foya, in the Serra de Monchique, province of Algarva, Portugal, as originally described by Blum,¹ are most nearly representative of the whole group. The term eleolite has fallen away, more or less, since the age element in mineralogy is no longer considered, and in general, in this country, the rocks have been called nephelite-syenites. Brögger² proposed to subdivide the nephelite-syenites into two groups according to texture. For rocks of this composition and with trachytoid texture he used Blum's term foyaite, and for those with granitic texture Zirkel's³ term ditroite. In the present classification, under the term nephelite-syenite, are included those nephelite-bearing rocks in which orthoclase exceeds acid plagioclase (oligoclase or andesine) in amount. The rocks in which the plagioclase is albite are here called albite-nephelite-syenites (2122), and those which contain no plagioclase, ortho-nephelite-syenites (212).

Foyaite BLUM-BRÖGGER.

Ditroite-ZIRKEL-BRÖGGER.

Syenoid SHAND. As an abbreviation for feldspathoid-syenite, Shand⁴ used syenoid, and said the term would "imply the presence of nephelite." He further suggested that gabbroid, dioroid, and doleroid might be advantageously coined in the same manner. Syenoid could well be used as a family name to include both nephelite and leucite rocks.

Leucite-syenite.

¹ R. Blum, "Foyait, ein neues Gestein aus Süd-Portugal," *Neues Jahrb.* (1861), p. 426.

² W. C. Brögger, *op. cit.*, *Zeitschr. f. Kryst.*, XVI (1890), pp. 39, 125; also *Die Eruptionsgesteine des Kristianiagebietes. III: Das Ganggefölge des Laurdalits* (Kristiania, 1898), pp. 164-65.

³ F. Zirkel, *Lehrbuch der Petrographie* (1st ed.; Bonn, 1866), I, 595. The term is derived from Ditró, in eastern Siebenbürgen, Transylvania.

⁴ S. J. Shand, "On Borolanite and Its Associates in Assynt," *Trans. Edinburgh Geol. Soc.*, IX (1910), 377.

(2223) **Nephelite-monzonite.** Under this name Lacroix¹ described rocks from Madagascar consisting essentially of anorthoclase, basic labradorite, nephelite, titaniferous pyroxene, bark-evikite, titaniferous magnetite, and apatite. The mineral proportions are quite variable. To make it conform with the usual monzonite group, the term nephelite-monzonite is here adopted for a nephelite rock of Class 2 with *acid* plagioclase about equal in amount to the other feldspars. The rock described by Lacroix is included under the calci-nephelite-monzonite family.

Nephelite (leucite-)latite. The extrusive equivalent of the preceding.

(2224) **Nephelite-(leucite-)monzodiorite.** A term here suggested for nephelite-(leucite-)bearing rocks comparable to granodiorites among the quartz-bearing.

(2225) **Nephelite-(leucite-)diorite.** A term, analogous to nephelite-syenite, here suggested for nephelite-acid plagioclase rocks. Under this family would fall Adams and Barlow's² raglanite, an abnormal rock on account of its large content of corundum, 4.45 per cent. Since it carries only 12 per cent by weight of nephelite, it is also far from the center point.

Nephelite-(leucite-)tephrites and nephelite-(leucite-)basanites belong here in part.

(2229) No plutonic rock has been located in this family, but there is an extrusive, a leucite-tephrite from the Roman Comagmatic region, described by Washington.³

(2230) A leucitite from the Roman Comagmatic region, described by Washington,⁴ is the only rock yet found here.

[To be concluded]

¹ A. Lacroix, "Sur les granites et syénites quartzifères à aegirine, arfvedsonite et aenigmatite de Madagascar," *Comptes Rendus*, CXXX (1900), 1208; also "Sur la province pétrographique de Nord-ouest de Madagascar," *ibid.*, CXXXII (1901), 439.

² Frank D. Adams and Alfred E. Barlow, "Geology of the Haliburton and Bancroft Areas, Province of Ontario," *Mem. Geol. Surv. Canada*, No. 6 (1910), p. 314.

³ Henry S. Washington, "The Roman Comagmatic Region," *Carnegie Publication*, No. 57 (Washington, 1906), p. 73.

⁴ *Ibid.*, p. 136.